

Switchable Shape Memory Alloys (SMA) Thermal Materials Project

Center Innovation Fund: KSC CIF Program
Office Of The Chief Technologist (OCT)

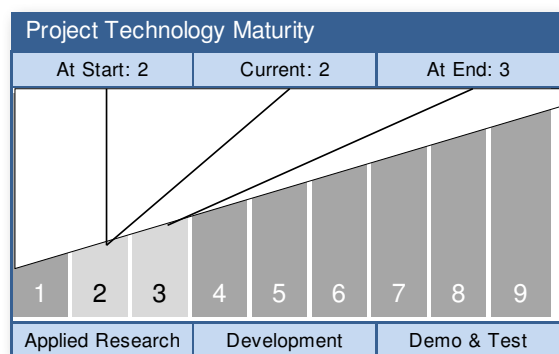
National Aeronautics and
Space Administration



ABSTRACT

Develop 2-way switchable thermal systems for use in systems that function in cold to hot temperature ranges using different alloy designs for SMA system concepts. In this project, KSC will specifically address designs of two proof of concept SMA systems with transition temperatures in the 65-95°C range and investigate cycle fatigue and “memory loss” due to thermal cycling.

SMA proof-of-concept test specimen



Technology Area: Materials, Structures, Mechanical Systems & Manufacturing TA12 (Primary)

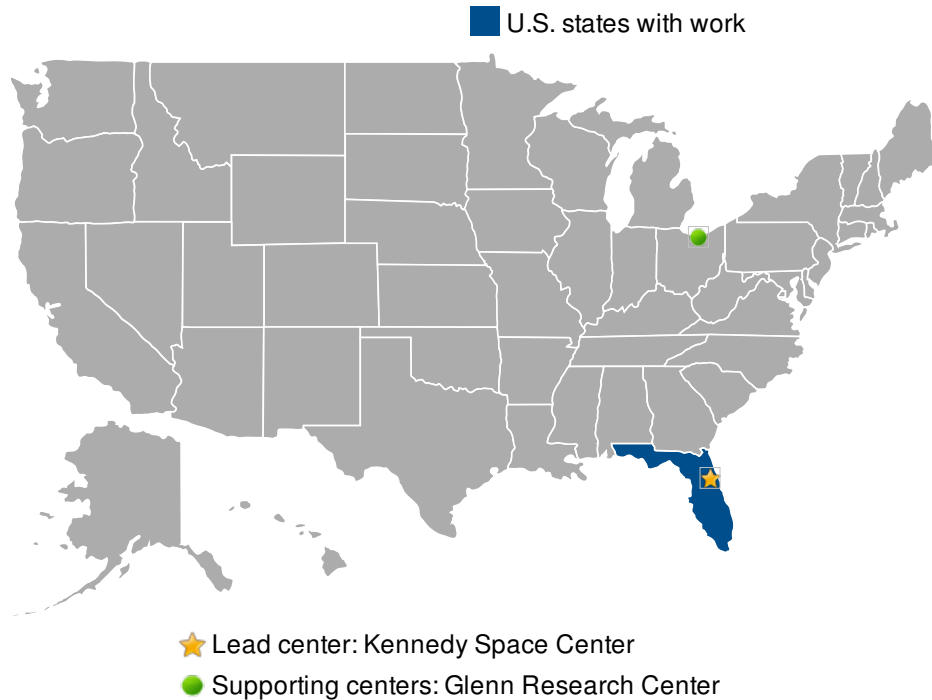
ANTICIPATED BENEFITS

To NASA unfunded & planned missions:

Current architectures require multiple systems and processes to perform different activities. A cryogenic tank fill requiring cool-down, for example, will also require warm-up as part of tank drain operations. Massive piping systems require a long time to cool down and a long time to warm up. This makes for inefficient control of fluids and increases system complexity, which increases safety risks and reducing overall operational costs. Future habitation architectures will also require significant thermal management.

The benefits to NASA include the...

Read more on the last page.



DETAILED DESCRIPTION

Shape memory alloys applies to a group of materials that demonstrate the ability to return to some previously defined shape when subjected to the appropriate thermal procedure. Generally, these materials can be plastically deformed at some relative lower temperature, and then upon exposure to some higher temperature will return to their original shape prior to the deformation. Materials that exhibit this property are referred to as one-way shape memory; some materials also undergo shape change upon re-cooling, and are referred to as 2-way shape memory. Generally, an alloy undergoes a transformation from the austenite phase to the martensitic upon strain below the transformation temperature, which is then reversed upon heating, returning to the parent phase. The only two alloys that have achieved any level of commercial exploitation are the NiTi alloys and the copper-base alloys, particularly CuAlNi and CuZnAl. In training and testing of these SMAs there are indications that they are susceptible to cycle fatigue depending upon conditions of use. In this project, two different novel designs previously developed are being enhanced and evaluated for cycle fatigue of the 2-way SMAs effects for use in intelligent thermal systems. Knowing the effective, efficient lifetime of each system, it will then be possible to design and optimize a system to a specific application in the future.

MANAGEMENT

Program Executive:
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Program Manager:
Nancy Zeitlin

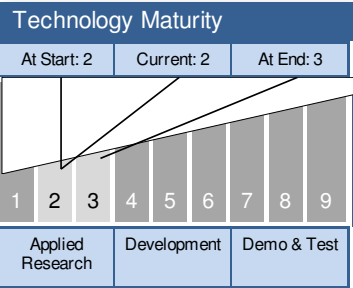
Project Manager:
Nancy Zeitlin

Principal Investigator:
Martha Williams

Co-Investigator:
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TECHNOLOGY DETAILS

Switchable Shape
Memory Alloys Thermal
Materials



TECHNOLOGY DESCRIPTION

- This project brings together novel, unique materials and transient thermal systems. The project utilizes specialty SMAs that can adapt under transient thermal management applications. Recent conceptual investigation of intelligent thermal systems to have dual-mode capability (conductive/insulative) depending on environmental conditions or applied stimuli shows the feasibility of such systems within a single architecture. Several proof-of-concept designs, including SMA based systems, were modeled and rudimentary breadboard samples fabricated for responsiveness within a very limited temperature range. This project addresses the evaluation of fatigue cycling parameters for two of those proof-of-concept designs.
- This technology is categorized as a hardware system for ground support or mission operations
- Technology Area
 - TA12 Materials, Structures, Mechanical Systems & Manufacturing (Primary)

CAPABILITIES PROVIDED

Shape memory alloys (SMAs) are rare alloys that exhibit the shape memory effect, which is the recovery of low temperature deformation in a material simply by heating the alloy through its phase transformation. These phase transformations can allow for novel designs of intelligent thermal management systems that has the capability of switching between a thermally insulated to a conductive state or mode within a single architecture. It is primarily designed to function in a passive manner, triggered by environmental or surrounding temperatures. The use of surrounding environments to add multi-functionality allows for more robust operations in such areas of cryogenic storage and transfer systems and in-situ resource utilization for space exploration.

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TECHNOLOGY DETAILS

POTENTIAL APPLICATIONS (CONT'D)

Efficient transient thermal management is a serious issue in both surface and space systems. For NASA it is especially critical to future exploration. It is important that innovative approaches to thermal control technologies be adaptive, multi-functional, and have a level of autonomy. The goal is to create entirely new classes of materials/systems that serve both structural and thermal functions and can be designed to manage heat energy in both transient and steady-state conditions. NASA must also try and understand “memory loss” and cycle fatigue of the Shape Memory Alloy (SMA) systems so that design requirements for efficiency can be defined.



IMAGE GALLERY



SMA proof-of-concept test specimen

ANTICIPATED BENEFITS

To NASA unfunded & planned missions: (CONT'D)

following:

- Increased controllability
- Reduction in energy and power usage
- Improved thermal management controls
- Reduced turnaround time
- Increased system availability
- Anticipated 50% reduction in loading time
- Reduction in commodity boil-off & helium usage

To other government agencies:

The technology is important to NASA and the military in meeting mission needs for high performance, lighter weight, intelligent thermal materials while meeting National needs in new materials for energy conservation, storage and transfer.

To the nation:

Benefits to military and industries, such as cryogenics, satellites, and commercial aircraft are also anticipated. A global effect could be realized in smart building materials and energy conservation.

